

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property
Organization
International Bureau



(43) International Publication Date
7 October 2004 (07.10.2004)

PCT

(10) International Publication Number
WO 2004/086461 A3

(51) International Patent Classification⁷: **H01L 21/338**,
21/072

(21) International Application Number:
PCT/US2004/008725

(22) International Filing Date: 22 March 2004 (22.03.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/456,770 21 March 2003 (21.03.2003) US
60/456,775 21 March 2003 (21.03.2003) US

(71) Applicant (for all designated States except US): **NORTH CAROLINA STATE UNIVERSITY** [US/US]; 2401 Research Drive, Suite 1122, Campus Box 8210, Raleigh, NC 27695-8210 (US).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **JOHNSON, Mark, Alan, Lamonte** [US/US]; 1023 West South Street, Raleigh, NC 27603 (US). **BARLAGE, Douglas, William** [US/US]; 2809 Montcastle Court, Durham, NC 27705 (US). **MUTH, John, Franklyn** [US/US]; 115 Beasley Court, Cary, NC 27513 (US).

(74) Agent: **WILSON, Jeffrey, L.**; Jenkins, Wilson & Taylor, P.A., University Tower, Suite 1400, 3100 Tower Boulevard, Durham, NC 27707 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

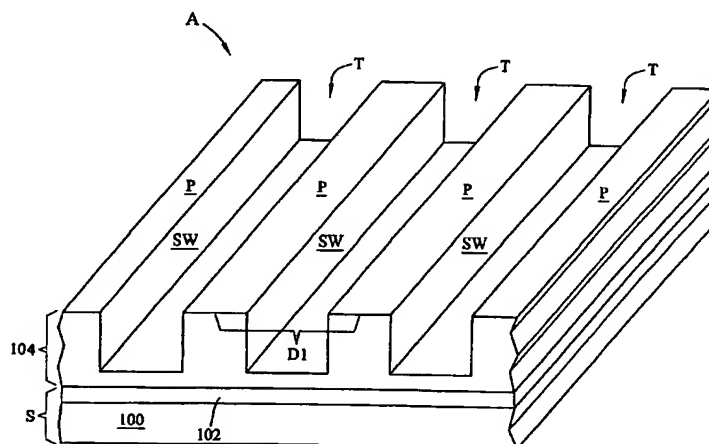
(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report

[Continued on next page]

(54) Title: METHODS FOR NANOSCALE STRUCTURES FROM OPTICAL LITHOGRAPHY AND SUBSEQUENT LATERAL GROWTH



(57) Abstract: Methods, and structures formed thereby, are disclosed for forming laterally grown structures (104) with nanoscale dimensions from nanoscale arrays which can be patterned from nanoscale lithography. The structures and methods disclosed herein have applications with electronic, photonic, molecular electronic, spintronic, microfluidic or nano-mechanical (NEMS) technologies. The spacing between laterally grown structures (104) can be a nanoscale measurement, for example with a spacing distance (D1) which can be approximately 1-50 nm, and more particularly can be from approximately 3-5 nm. This spacing (D1) is appropriate for integration of molecular electronic devices. The pitch between posts (P) can be less than the average distance characteristic between dislocation defects for example in GaN ($p = 10^{10}/\text{cm}^2 \rightarrow d = 0.1 \mu\text{m}$) resulting an overall reduction in defect density. Large-scale integration of nanoscale devices can be achieved using lithographic equipment that is orders of magnitude less expensive than used for advanced lithographic techniques, such as electron beam lithography.

WO 2004/086461 A3



— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(88) Date of publication of the international search report:

14 April 2005

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US04/08725

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : H01L 21/338, 21/072

US CL : 438/167; 257/194

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 438/167, 172, 180; 257/192, 194, 195, 196; 977/ DIG.1

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Please See Continuation Sheet

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,151,757 A (Enoki et al.) 29 September 1992 (29.09.1992), Figs. 1, 4, 5, 6, and 7.	1-69
Y	US 5,838,030 A (Liu et al.) 17 November 1998 (17.11.1998), Fig. 1.	1-69
Y	US 6,242,293 B1 (Danizilio) 05 June 2001 (5.06.2001), Figs. 1, 4, 12.	1-69
Y	US 6,008,509 A (Inai et al.) 28 December 1999 (28.12.1999), Figs. 1A, 1B, 2, 3, 4.	1-69
Y	US 6,309,580 B1 (Chou) 30 October 2001 (30.10.2001) Figs. 1A, 1C, 1D, 2, 3, 4, 5A, 5B, 6, and 7.	1-69
Y,P	US 6,566,704 B2 (Choi et al.) 20 May 2003, Figs. 3B, 3C, and 3D.	1-69
Y,P	US 6,593,065 B2 (Scherer) 15 July 2003 (15.07.2003), Figs. 1a - 1d, 4, 5a-5f, and 6a-6c.	1-69
Y,E	US 6,755,984 B2 (Lee et al.) 29 June 2004 (29.06.2004), Figs. 1-5, 11a-11b, 12a-12c, and 17-19.	1-69

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T"

later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X"

document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y"

document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"

document member of the same patent family

Date of the actual completion of the international search

25 January 2005 (25.01.2005)

Date of mailing of the international search report

28 FEB 2005

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US

Commissioner for Patents

P.O. Box 1450

Alexandria, Virginia 22313-1450

Facsimile No. (703) 305-3230

Authorized officer

Olik Chaudhuri

Telephone No. (571) 272-1855

INTERNATIONAL SEARCH REPORT

PCT/US04/08725

Continuation of B. FIELDS SEARCHED Item 3:

EAST (USPAT, USPGPUB, EPO, JPO, DERWENT, IBMTDB)

nano with trench; nano with width; gallium nitride or GaN; pitch; nano with width; nanoscale with pattern\$3; nanoscale near5 lithography.